PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

1834–35. No. 5.

December 1.

SIR THOMAS MAKDOUGALL BRISBANE, K. C. B. President, in the Chair.

The following Donations were presented :—

An Essay on the Deaf and Dumb; shewing the necessity of Medical Treatment in Early Infancy; with Observations on Congenital Deafness. By John Harrison Curtis, Esq.—*By the Author.*

The Quarterly Journal of Agriculture; and the Prize Essays and Transactions of the Highland and Agricultural Society of Scotland, for September 1834.—*By the Highland and Agricultural Society of Scotland.*

Reports of the Scarborough Philosophical Society, for 1831, 1832, and 1833.—*By the Society.*

Bulletin de la Société Géologique de France, Tome iv. Feuilles 10–24; and Tome v.—*By the Society.*

Archiv fur Chemie und Meteorologie, herausgegeben vom Dr K. W. G. Kastner. Bands 1, 2, 3, 4, 5, 6, and Band 7, Heft 1. —*By the British Association.*

Quelques Observations de Physique Terrestre. Par MM. Aug. De La Rive, and F. Marcet.—*By the Authors.*

Esquisse Historique des Principales Découvertes faites dans l'Electricité depuis quelques Années. Par M. Auguste De La Rive. —*By the Author.*

Notice Biographique sur M. le Professeur G. De La Rive.—*By the Author.*

Bulletins de l'Académie Royale des Sciences et Belles Lettres de Bruxelles. Nos. 19–24.—*By the Society.*

Annales de l'Observatoire de Bruxelles, publiées par le Directeur, A. Quetelet. Part 1.—*By the Author.*

Astronomische Beobachtungen auf der Königlichen Universitäts Sternwarte in Königsberg. Von F. W. Bessel, for 1830.—*By the Author.*

Astronomische Nachrichten. Nos. 258–264.—*By Professor Schumacher.*

Transactions of the Royal Irish Academy. Vol. xvii. part 1.

Asiatic Researches—Transactions of the Physical Class of the Asiatic Society of Bengal. Vol. xviii. Part 2.—*By the Society.*

A Treatise on Insects, being the article Entomology, from the 7th Edition of the Encyclopædia Brittannica. By James Wilson, Esq.—*By the Author.*

Nova Acta Regiæ Societatis Upsaliensis. Vol. x.—*By the Society.*

The Journal of the Royal Asiatic Society of Great Britain and Ireland. No. 1.—*By the Society.*

Transactions of the Royal Asiatic Society. Vol. iii. Part 3.—*By the Society.*

A Manual of Mineralogy, comprehending the more recent Discoveries in the Mineral Kingdom. By Robert Allan, Esq.—*By the Author.*

Transactions of the Zoological Society of London. Vol. 1. Part 2; and

Proceedings of the Zoological Society of London. 1833; Part 1.—*By the Society.*

The American Journal of Science and Arts, conducted by Benjamin Silliman, M. D., LL. D. For April and October 1834.—*By the Editor.*

The Climate of London deduced from Meteorological Observations made in the Metropolis, and at various places around it. By Luke Howard, Esq. 3 vols.—*By the Author.*

Proceedings of the Fifteenth Anniversary Meeting of the Hunterian Society, held on the 4th February 1834, with the Report and List of Officers and Members.—*By the Society.*

A Practical and Pathological Inquiry into the Sources and Effects of Derangements of the Digestive Organs. By William Cooke, Esq.—*From the Author.*

Fauna Americana, being a Description of the Mammiferous Animals

inhabiting North America. By Richard Harlan, M. D.—*From the Author.*

Proceedings of the Geological Society of London. Nos. 33, 34, and 35.—*From the Society.*

Report of the Managers of the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, in relation to Weights and Measures.—*From the Institute.*

Bulletins de la Société d'Encouragement pour l'Industrie Nationale, 1833 and 1834; January to April.—*From the Society.*

Mémoires de l'Institut Royal de France.—Académie des Inscriptions et Belles Lettres. Tome x.—*From the Institute.*

Conjectures concerning the Origin of Alphabetic Writing. By Thomas Stephens Davies, Esq.—*From the Author.*

Transactions of the Linnean Society of London. Vol. xvii. Part 1. —*From the Society.*

Memoirs of the Royal Astronomical Society. Vol. vii.—*From the Society.*

Transactions of the Cambridge Philosophical Society. Vol. v. part 2. —*From the Society.*

Nautical and Hydraulic Experiments, with numerous Scientific Miscellanies. By Colonel Mark Beaufoy, F. R. S. Vol. i.—*By the Editor.*

Transactions of the American Philosophical Society, held at Philadelphia, for Promoting Useful Knowledge. Vol. iv. New Series, Part 3.—*From the Society.*

Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin, 1832.—*From the Academy.*

An Engraving of the Royal William Yard, Plymouth. By J. Rennie, Esq.—*From J. Rennie, Esq.*

Mémoires de la Société d' Agriculture, from 1814 to 1833. 25 Tomes.—*From the Society.*

Rapport au Conseil Supérieur de Santé sur le Choléra Morbus Pestilentiel. Par Alexandre Moreau de Jonnès.—*From the Author.*

Statistique de l'Espagne. Par Alexandre Moreau de Jonnès.—*From the Author.*

Histoire Physique des Antilles Françaises. Par Alexandre Moreau de Jonnès.—*From the Author.*

Origines Biblicæ; or Researches on Primeval History. By Charles Tilstone Beke, Esq. Vol. i.—*From the Author.*

Population Abstracts of Great Britain. 3 vols.—*From J. Rickman, Esq.*

Proceedings of the Royal Society. No. 15.

Transactions of the Royal Society of London, 1834. Part 1.—*From the Society.*

Elements of Chemistry, including the recent Discoveries and Doctrines of the Science. By Edward Turner, M. D., F. R. S. L. and E. Fifth edition.—*From the Author.*

Astronomical Observations made at the Royal Observatory at Greenwich, under the direction of John Pond, Esq., Astronomer-Royal, for the years 1831 and 1832; January to September.—*From the Royal Astronomical Society.*

Observations Sommaires, sur les Canaux Navigables, et les Chemins de Fer, et sur les avantages que la France peut obtenir de sa Canalisation, notamment pour la prosperité de son Agriculture. Par M. Huerne de Pommeuse.—*From the Author.*

A Cameleon, a Fly Fish, and a Lantern Fly, preserved in spirits.—*From John Gordon, Esq.*

The following Communications were read:—

1. On Phosphuretted-Hydrogen Gas. By Thomas Graham, Esq., Glasgow.

It is well known that chemists have usually admitted the existence of two gaseous compounds of phosphorus and hydrogen,—one spontaneously inflammable, the other not so. Of late, *Rose* of Berlin has ascertained that both gases are identical in composition, and has consequently been led to infer that the existence of two phosphuretted-hydrogens, differing so much in properties, and yet similarly composed, constitutes an example of isomerism among gaseous bodies.

Mr Graham, however, shows in his paper that this inference is not borne out by the facts of the case,—that there are not two phosphuretted-hydrogens,—and that the spontaneous inflammability of the gas obtained by heating together phosphorus, lime, and water, is an accidental property, which may be removed by a variety of agents, without altering the constitution of the gas, and which may also be restored to such gas, as well as communicated to that which is not in the first instance spontaneously inflammable.

The agents which exercise the most remarkable power in destroying the property of spontaneous inflammability are, *in the first instance*, various other gases, such as hydrogen, sulphuretted-hydrogen,

olefiant gas, nitric oxide gas, carbonic acid, nitrogen, ammonia, or muriatic acid gas, which, in a proportion varying from a twentieth of a volume to five volumes, will at once take away the property in questions;—*secondly*, certain porous bodies, more especially charcoal;—*thirdly*, various acids, such as sulphuric, arsenious, phosphorous, and phosphoric acids;—*fourthly*, solution of caustic potass and potassium;—*fifthly*, alcohol, ether, naphtha, and the various essential oils. These substances produce their effect sometimes in most minute proportions, commonly in a very short space of time, and without necessarily occasioning any change in the volume of the gas, or any other alteration whatever, except simply the loss of the property of kindling spontaneously on its coming in contact with the air.

The only agent which the author has found to possess the power of restoring spontaneous inflammability to gas which has been deprived of that property, by keeping or otherwise, is nitrous acid vapour. A large proportion of this vapour has no such effect, but a small proportion, varying between a thousandth and a ten-thousandth of the gas, will immediately communicate the property of kindling spontaneously in the air, even to the phosphuretted-hydrogen prepared by heating hydrated phosphorous acid, which variety of gas is well known to be always naturally destitute of this remarkable character.

Gas which has been rendered spontaneously inflammable in this way is similarly acted on by keeping, by other gases, by acids, by potassium, and by the hydrocarburets, as the common phosphuretted-hydrogen, prepared from lime and phosphorus.

The author concluded his observations by stating, that the analogous action of nitrous acid, and the circumstance that the agents which take away the property of inflaming spontaneously are chiefly deoxidating substances, would lead to the conjecture that this property is owing to the accidental presence of a minute trace of a compound of oxygen and phosphorus not hitherto known, but analogous in composition to nitrous acid among the compounds of oxygen and nitrogen. On account of the extremely minute proportion in which it exists in the spontaneously inflammable phosphuretted-hydrogen gas, he was unable to insulate it. But an important additional reason for believing in its existence appears to the author to be the fact, that while the compounds of phosphorus and of nitrogen severally with oxygen coincide in composition in other respects, an oxide of phosphorus has not yet been discovered which coincides in composition with nitrous acid among the oxides of nitrogen.

2. On the Fossil Fishes of the Limestone of Burdiehouse. By Dr Hibbert.

In this paper the author gave an account of a communication received by him from M. Agassiz, Professor of Natural History at Neuchâtel in Switzerland, relative to the remains of fishes which had been discovered in the limestone of Burdiehouse, and which had been submitted to his examination. As many of the fish discovered would be explained in his "Recherches sur les Poissons Fossiles," an opinion upon a few only was requested.

The genus found in greatest abundance had been referred by Dr Hibbert to the Palæoniscus, which view was confirmed by M. Agassiz, who, in pointing out its distinction from the Palæoniscus angustus of Autun, which it most resembled, regarded it as a new species. This very characteristic fish of the limestone of Burdiehouse, Dr Hibbert has named Palæoniscus Robisoni, in honour of Mr Robison, General Secretary of the Royal Society of Edinburgh. Another fossil fish of a new and extraordinary genus, received the name of Eurynotus crenatus. A third, which was the first animal relic discovered by Dr Hibbert in the quarry of Burdiehouse, was named, at his request, the Pygopterus Bucklandi.

The bony rays, of immense dimensions, and beautifully configurated, in the possession of the Royal Society of Edinburgh, M. Agassiz refers to a new genus of fish; and he proposes to name the individual to which they belong the Gyracanthus formosus. He is also inclined to refer to the same individual certain teeth found in another locality near Edinburgh. This genus belongs to his Placoidian order, and to the family of Cestraciontes, so named from their approach to the Cestracion of New Holland. With regard to the alleged Saurian character of the teeth, scales, and some of the large bones discovered in the quarry of Burdiehouse, M. Agassiz was induced to consider them as *Sauroid*, rather than exactly Saurian, and to assign them to a large sauroid fish, akin to the extant Lepidosteus. In the form of its teeth, and in a very near resemblance of its scales to those of a reptile, the Lepidosteus agrees with Crocodilean families. Nor does this general correspondence fail, even with regard to the internal structure of the animal. M. Agassiz has described the result of an investigation of the swimming bladder of a specimen of the Lepidosteus spatula, preserved in spirits, from the dissection of which he was enabled to demonstrate, not only that it is a real lung, but that it even approaches closely to the structure of the lungs of reptiles,

having characters in common with the lungs of salamanders, and of the reptiles improperly called doubtful reptiles. The lung or swimming bladder of the Lepidosteus is not only cellular, but has also a trachea, which extends the whole length of its anterior surface, and communicates with a glottis, surrounded by ligaments, intended to open and shut it, constituting an apparatus even more complicated than what is found in many reptiles. M. Agassiz also adds, that the heart has not the appearance of that of a common fish: it is destitute of the inflation named bulbus aorticus, so characteristic of fish, and hence has much more the aspect of the heart of a reptile.

With this fish, in its well marked external characters, M. Agassiz has compared the sauroid relics discovered at Burdiehouse, and, in this inquiry, he has been assisted by the entire head of a large fossil fish, preserved in the museum of Leeds. From the aid thus derived, he has been enabled to establish a new genus under the name of Megalichthys. With regard to the scattered and disjointed bones found at Burdiehouse, it is conceived that they indicate a distinct species, to which M. Agassiz has some time since given the name of Megalichthys Hibberti. To the remains of another species of the same genus, discovered near Glasgow, and distinguished by a greater flatness of its teeth, M. Agassiz is disposed to assign the appellation of Megalichthys falcatus.

In concluding the account of this investigation, Dr Hibbert made some observations on the importance in geology of selecting for purposes of close comparison and analogy, animals subsisting in recent times, which may be adjudged to bear the nearest affinity to races long since extinct. In the present instance, the discrimination and talents of M. Agassiz had been enabled to rescue from obscurity a sauroid fish dwelling among the lakes and rivers of the most thermal regions of America, and to render it elucidative of one of the earliest states of our planet, when, in the language of this naturalist, fish united in their particular organization the character of reptiles belonging to that class of animals which only appeared in far greater numbers during a later epoch.

December 15. 1833.

JAMES RUSSELL, Esq., Vice-President, in the Chair.

The following Donations were presented :—

Mémoires de l'Académie Impériale de St Petersbourg (Sciences Mathématiques, &c.) Tome ii. Livraisons 5 et 6.

Mémoires de l'Académie Impériale de St Petersbourg, (Sciences Politiques, &c.) Tome ii. Livraisons 2, 3, 4, 5.

Mémoires de l'Académie Impériale de St Petersbourg (par divers Savans.) Tome ii. Livraisons 1, 2, 3.

Recueil des Séances publiques de l'Académie Impériale de St Petersbourg, tenues en Décembre 1826, Decembre 1827, and Decembre 1833.

Transactions of the Royal Society of Literature of the United Kingdom. Vol. 2.—*From the Society.*

Mémoires de la Société de Physique et d'Histoire Naturelle de Geneve. Tome vi.—*From the Society.*

The following Communications were read :—

1. General Remarks on the Coal-Formation of the Great Valley of the Scottish Lowlands. By Major-General Lord Greenock.

In this paper the author stated, that although there is sufficient evidence in the mechanical origin and organic contents of the beds (some of them of extraordinary thickness and extent), which form the coal-measures, to prove the pre-existence of much larger tracts of dry land, in connection with each other, than could possibly have been afforded by the older portions of the present countries; such proofs are altogether wanting when we endeavour to restore, in imagination, what might have been the probable extent of that land, the greater part of which may now lie buried beneath the ocean, or have since been covered by more recent deposits. It appears, however, to have been clothed with a luxuriant tropical vegetation, and sufficiently elevated to have given rise to the rivers and torrents, by which the materials for composing the coal strata had been carried down into the lakes or estuaries, where to all appearance they were deposited.

The circumstances in which the large fossil trees are seen imbed-

ded in the strata of the coal-measures, and other similar phenomena, have led the author to suppose, that these rivers and their estuaries may have been of greater magnitude than would probably have been the case if they had been situated in small islands, according to the opinion of many geologists. The intermixture of terrestrial and marine remains in the same beds, is a strong evidence in favour of their fluviatile origin; and the fact frequently observed, of these beds being covered by, or alternating with, others containing only marine remains, may, with great probability, be referred to changes in the relative level of the land and sea that may have taken place while these deposits were forming.

In the author's opinion, it is still doubtful whether any beds have yet been discovered in this series which may be considered to be exclusively of fresh-water origin, unless an exception should be found in the limestone noticed by Mr Murchison at Ponterburg in Shropshire. M. Agassiz has shewn, that neither the Burdiehouse limestone, nor any of the other beds of the Scottish coal-fields with which we are at present acquainted, is of that character; nevertheless the limestone at Burdiehouse is a very remarkable deposit; and the discoveries of Dr Hibbert with reference to that locality, are of the highest geological importance.

The author then proceeded to describe the limits within which the coal appears to have been deposited in the Scottish Lowlands, which, with the exceptions pointed out by him, may, according to Williams, be indicated by a line drawn from the mouth of the Tay passing through Stirling, to the northern extremity of Arran; and another nearly parallel to it from St Abb's Head on the east coast, to Girvan on the west. Although coal may not have been equally distributed in every part of this district,—the deposition of the vegetable matter from which it was derived, having probably been more or less influenced by local circumstances, which may also have caused occasional varieties in the mineral structure and organic contents of the associated strata,—yet, in the opinion of the author, there are sufficient grounds to justify the conclusion, that the whole series originally constituted one great formation, the strata of which it is composed appearing to have been deposited continuously, more or less, in a horizontal position at the bottom of the sea, that must then have covered at least the whole of that portion of the Lowlands, forming either a strait or channel between two islands, or perhaps a vast estuary in which the rivers of the neighbouring primeval countries discharged their waters. The ripple-marks observable on the surface

of most of these beds give much additional probability to this supposition.

This original continuity of the beds occupying the carboniferous district, appears to have been subsequently interrupted by the intrusion of the igneous rocks and hills so universally prevalent in that formation, by which they have been separated into the fields or basins where they are now found. The effects of Plutonic action, by which these hills were produced, seem to have been the chief agents employed in modifying the external surface of this important district, and occasioning those chemical changes and combinations in the interior of the earth, by which, when elevated above the waters, it was destined to become a more suitable habitation for the human race.

The Pentland, Campsie, and Ochil hills, as well as many others of a similar description within the limits specified, afford striking examples of the effects produced by their intrusion among the coal strata, at periods subsequent to the consolidation of the latter, of which some instances were noticed by the author. In fact, the whole country occupied by the Scottish coal-measures, displays more or less the influence of such igneous hills, or of the dykes connected with them. A certain degree of parallelism may be traced between the principal ranges, their general bearing being from the eastward of north to the westward of south, which corresponds with the general strike of the fossiliferous strata; but they often appear to have been protruded through the surface without any order or regularity, and the dykes are found to proceed in every direction from the principal masses.

The author farther remarked, that rivers, estuaries, or portions of the sea, now flow through or cover strata of this coal formation, which, from the appearances on their opposite shores, were in all probability once continuous. The connection between the Lothian coal-fields and that of Fifeshire is very apparent, both in the general direction of the strata, as seen by their outcrop on the opposite shores of the Frith of Forth, and in the number and thickness of the beds of coal in each, which exactly correspond. The appearance of the carboniferous series in Arran, and at Campbelton in Kintyre, as well as the indications of its existence at Ballycastle, and other places on the Irish coast, within the prolongation of the lines before adverted to, seems fully to establish the geological connection in this, as well as in most other respects, between the west of Scotland and the north-east of Ireland.

In regard to the age of the Scottish coal-measures as compared

with those of England, the author observed that no formations of a more recent date than the coal series have been met with in the Scottish Lowlands, for the red sandstones of that district do not appear in any instance to have been identified with the new red sandstone of England. Professor Sedgwick and Mr Conybeare have stated some strong reasons, which incline him to refer these Scottish coal-measures to the lower beds of the carboniferous limestone group; and Mr De la Beche has been led by similar considerations to the conclusion, that at the period when the carboniferous limestone of the south of England was produced in the sea, there was probably dry land in the part of the European area not far to the northward of the present Tweed, and that a gradual rise of the land was effected, by which means terrestrial vegetation travelled farther to the south, so that its remains became abundantly entombed in that direction, producing the coal now found in southern England and Wales, as also in Belgium and northern France, the continuity of the whole being superficially concealed by the secondary and tertiary deposits of those countries. But, as Mr De la Beche justly observes, to trace even the probable extent of dry land over the European area at the carboniferous epoch, would be most difficult, particularly when we recollect that what we term a geological epoch may include a long series of ages.

2. On the composition of the Rangoon Petroleum, with Remarks on the composition of Petroleum and Naphtha in general. By William Gregory, M.D. F.R.S.E.

The author first adverted to the discovery, nearly about the same time, of paraffine by Reichenbach and of petroline by Dr Christison. The former occurred among the products of destructive distillation; the latter was found in the Rangoon petroleum, and they were soon found to be identical. Reichenbach's researches on naphtha were then quoted, by which it appears that that indefatigable observer could not discover, in the kind of naphtha which he examined, any trace either of paraffine, or of any other product of destructive distillation. On the contrary, he found that naphtha to possess the characters of oil of turpentine, a product of vegetable life; and he succeeded in obtaining a precisely similar oil from brown coal by distillation at 212°. These facts had led Reichenbach to the conclusion that naphtha in general is not a product of destructive distillation, and, consequently, must have been separated at a comparatively low

temperature. The author showed that Dr Christison's discovery of paraffine, of which Dr Reichenbach was necessarily ignorant, is inconsistent with this view; and detailed some experiments, by which he has rendered highly probable the existence in petroleum of eupion, another of the products of destructive distillation. This substance is a liquid of Sp. gr. 0.655, boiling at 110°, and very fragrant. The author obtained from the Rangoon petroleum a liquid of Sp. gr. 0.744, boiling at 180°, and rather fragrant. The oil of turpentine, as is well known, boils at 280, and has a Sp. gr. of 0.860; so that, at all events, the naphtha from the Rangoon petroleum is not oil of turpentine. This was farther proved by the tests of nitric acid and iodine. Similar experiments on one or two other species of naphtha led to similar results. They all yielded a liquid of Sp. gr. about 760, and, consequently, could not be oil of turpentine. The kinds of naphtha tried were Persian naphtha, obtained from Dr Thomson, and commercial naphtha, sold by M. Robiquet of Paris.

The author concluded, that if the naphtha examined by Reichenbach were genuine, there must be at least two kinds of naphtha; one a product of destructive distillation, the other the oil of turpentine of the pine forests of which our coal-beds are formed, separated by a gentle heat, either before or after their conversion into coal. It is obvious that our common coal-beds have never yet been exposed to a heat sufficient for destructive distillation, since they are destroyed by a moderate heat, and we may therefore expect the petroleum of these coalbeds to be of the kind described by Reichenbach; while the Rangoon and Persian petroleums, being products of destructive distillation, must have their origin, if in coal-beds at all, in such as have been exposed to a high temperature, and must, consequently, be very different from the ordinary coal-beds. In confirmation of this view it may be stated, that Dr Christison could find no paraffine either in the petroleum of St Catherine's, or in that of Trinidad or Rochdale.

The author finally directed attention to the application of the paraffine as a material for giving light, as, when pure, it burns with a clear bright flame, like that of wax, and might doubtless be obtained at a cheap rate in the East.

January 5. 1835.

SIR T. M. BRISBANE, President, in the Chair.

The following Donations were presented.—

Astronomische Nachrichten, Nos. 265, 266, and 267.—*From Professor Schumacher.*

Distances of the Sun, and the four planets, Venus, Mars, Jupiter, and Saturn, from the Moon, calculated according to Mr Bessel's method, together with their places for every day in the year 1835. Calculated under the direction of H. C. Schumacher, Professor of Astronomy at Copenhagen, &c.—*From the Author.*

Proceedings of the Berwickshire Naturalists' Club. No. II.—*From the Club.*

Kongl. Vetenskaps-Academiens Handlingar för Ar 1833.

Arsberättelser om Vetenskapernas Framsteg, afgifne af Kongl. Vetenskaps-Academiens Embetsmän, D. 31 Mars 1833.—*From the Academy.*

Series of Geological Specimens, illustrative of the Greywacke series of Shropshire, Herefordshire, Gloucestershire, and Wales.—*Presented to the Society by Mr Murchison.*

The following communication was read:—

On Water as a constituent of Salts. By Tho. Graham, Esq.

1. In the case of the Sulphates.

That water may act the part of a *base* in the constitution of certain hydrates of salts and of acids, had been established by the author in the case of the phosphates. The peculiarity of phosphoric acid is its capacity to unite with water as a base in several proportions, while all other acids combine with water as a base in one proportion only, so far as is yet known. By the author's discoveries in regard to phosphoric acid, the ordinary conceptions entertained of the constitution of salts were completely deranged. The salts called biphosphate of soda, phosphate of soda, and subphosphate of soda, were proved to be all tribasic salts. The common idea of a super-salt is inapplicable to any of them.

In certain salts the author has subsequently found water to exist in a different state, not possessed of a true basic function, being re-

placeable by a *salt*, and not by an alkaline base. To develope this new function of water, in the case of the sulphates, was the object of the present communication. In that well known class of sulphates, consisting of sulphates of magnesia, zinc, iron, manganese, copper, nickel, and cobalt, all of which crystallize with either five or seven atoms of water, one atom proved to be much more strongly attached to the salt than the other four or six, which last generally may be expelled by a heat under the boiling point of water, while the last atom uniformly requires a heat above 400° Fahrenheit for its expulsion, and seems to be in a manner essential to the salt. The constitution of crystallized sulphate of zinc, for instance, may be expressed thus:

$$\dddot{S}\dot{Z}\dot{H}+\dot{H}^{6}.$$

The seven atoms of water are here divided into one atom, which is essential to the constitution of the salt, as we know it, and six atoms which are not so; and to this last quantity the name "water of crystallization" may be restricted. Now, in the double sulphate of zinc and potash, the single atom of water pertaining to the sulphate of zinc is replaced by an atom of sulphate of potash, and the six atoms of water of crystallization remain. Sulphate of magnesia combines with sulphate of potash after the same manner, and so do all the other salts of this class. The constitution of the crystallized sulphate of zinc and potash, which may be taken as the type of this family of double salts, is therefore represented by the following formula:—

$$\dddot{S}\dot{Z}(\ddot{S}\dot{K})+\dot{H}^{6};$$

which differs only from the previous formula in having the sign of sulphate of potash ($\ddot{S}\dot{K}$) substituted for the sign ($\dot{H}$) of the essential atom of water.

From a contemporaneous examination of the supersulphates, the conclusion proved to be inevitable that they also are double salts; that the bisulphate of potash, for instance, is a sulphate of water and potash, and that its formula is as follows:—

$$\dddot{S}\dot{H}(\ddot{S}\dot{K}),$$

with or without water of crystallization in addition. There is likewise a provision in the constitution of hydrated sulphuric acid for the production of such a double salt, as in the case of sulphate of zinc. Hydrated sulphuric acid of specific gravity 1.78 contains two atoms of water, and is capable of crystallizing at a temperature so high as

40° Fahrenheit. It is the only known crystallizable hydrate of sulphuric acid, and may be represented thus:—

$$\ddot{S}\dot{H}\dot{H},$$

which may be compared with the formula for sulphate of zinc, without water of crystallization—

$$\ddot{S}\dot{Z}\dot{H}.$$

This second atom of water present in hydrated sulphuric acid is replaceable by sulphate of potash, a salt; and the bisulphate of potash results from the substitution. But the first atom of water in the acid hydrate can be replaced only by an alkali or true base. The function of the first atom is *basic*, but a new term is required to distinguish the function of the second atom. The application of the epithet *saline* to that atom of water may perhaps be permitted, to indicate that it stands in the place of a salt. The hydrate of sulphuric acid in question contains, therefore, an atom of basic and an atom of saline water. It is "a sulphate of water with saline water," as hydrous sulphate of zinc is "a sulphate of zinc with saline water." The bisulphate of potash is also "a sulphate of water with sulphate of potash," and corresponds with the sulphate of zinc and potash, which last is "a sulphate of zinc with sulphate of potash."

Sulphuric acid of sp. gr. 1.78 is therefore the primary salt, and gives the character of the sulphates. This acid hydrate corresponds closely with the sulphate of magnesia, which is the reason they do not combine together. Hence there are no acid or super sulphates of magnesia, zinc, &c.

Of the two atoms which hydrated sulphate of lime, or gypsum, contains, one is expelled at 212° in vacuo; and the other, which is the saline atom, is not retained at a higher temperature than 300°. Hence sulphate of lime has less disposition to form double sulphates than the sulphate of magnesia, &c.

Professor Forbes announced the results of an Experimental investigation into the Polarization and Refraction of Heat. The reading of the paper on this subject was commenced.

19*th January.*

Dr HOPE, V. P. in Chair.

The following Donations were presented :—

Report to the Committee of the Commissioners of Northern Lights, appointed to take into consideration the subject of Illuminating the Lighthouses by means of Lenses. By Alan Stevenson, M.A. Civil-Engineer.

Bulletin de la Société Geologique de France. Tome iv. Feuilles 28, 29.

The following communications were read :—

1. On the Refraction and Polarization of Heat. By Professor Forbes.

The FIRST SECTION of this paper contains an account of a variety of experiments undertaken with the thermo-multiplier of Nobili and Melloni, the instrument exclusively employed in the subsequent researches. By a comparison of its sensibility with that of air-thermometers, the author concludes that one degree of deviation of the needle of the multiplier corresponds to an effect indicated by about one-fiftieth of a centigrade degree on the others. Without increasing the dimensions of the multiplier, by which its sensibility would be impaired, he has been enabled, by an optical contrivance, readily to measure one-tenth of one of its degrees, corresponding to one-five hundredth of a centigrade degree. From an experiment intended to detect the heat of the lunar rays, concentrated by a polyzonal lens, thirty-two inches in diameter, and acting upon this instrument, he concludes that the direct effect of the moon upon an air-thermometer probably does not amount to *one-three hundred thousandth* part of a centigrade degree.

After mentioning his repetition of M. Melloni's experiments upon the refraction of heat, the author proceeds, in the SECOND SECTION, to give an account of his own researches on the action of tourmaline on heat. At first he found (as it afterwards appeared M. Melloni had done) that no more heat was stopped when the tourmaline plates had their axes crossed, or transmitted least light, than when they were parallel, or transmitted most. He afterwards detected a fallacy in his mode of operation, and proved the polarization of heat, whether luminous or obscure, by tourmaline.

The THIRD SECTION treats of the polarization of heat by refraction

and reflection. The former method the author found by far the most convenient, employing thin plates of mica, arranged at the polarizing angle, and through which even dark heat was very freely transmitted. The results were so marked that they were verified in a great variety of ways, and with heat from sources extremely different, as that of an argand lamp, and of water below 200° Fahr. The polarization of non-luminous heat by *reflection* was also established, though with much less ease and simplicity. In this form it was announced by Berard about twenty years ago, but hitherto his experiment does not appear to have been repeated with success.

The FOURTH SECTION considers the modifications which polarized heat undergoes by the action of doubly refracting crystals. The analogies here are derived entirely from those of light. Very numerous experiments are quoted to shew that the effects are quite analogous, even when the source of heat is water under the boiling point. The doubly refracting substance used to depolarize was generally mica. Out of 157 recorded experiments on depolarization, with three different mica plates, only one gave a neutral and one a negative result. Yet of these 157 experiments, no less than 92 were made with heat unaccompanied by any visible light. One very striking experiment is quoted in illustration of the marked nature of the effects. When the polarizing and analyzing plates were situated so as to transmit least heat to the pile, and a thin film of mica was interposed between the plates in such a position as would depolarize light under similar circumstances, the film was found to *stop* more heat than it *depolarized*, or the needle moved towards zero; but if a mica film much *thicker* (so much thicker as to stop *more than twice* as much common heat as the first) was similarly placed, that film *depolarized* more than it *stopped*, and the needle moved in the opposite direction to the former one. The investigation of the laws of depolarization given in this section are hardly capable of abridgement.

The following are the general conclusions :—*

1. Heat, whether luminous or obscure, is capable of Polarization by Tourmaline.
2. It may be pol[illegible]zed by Refraction.
3. It may be polarized by Reflection.
4. It may be depolarized by Doubly Refracting Crystals. Hence—
5. It is capable of double refraction, and the two rays are polarized. When suitably modified, these rays are capable of interfering, like those of light.

* These conclusions were stated nearly in these words (except the 6th) to the Royal Society on the 5th January.

6. The characteristic law of polarization in the case of light holds in that of heat; viz. that the intensities in rectangular positions of the polarizing and analyzing plates are complementary to each other.
7. As a necessary consequence of the above, confirmed by experiment, heat is susceptible of circular and elliptic polarization.
8. The undulations of obscure heat are probably longer than those of light. A method is pointed out of deducing their length numerically.

2. Supplementary Notice on the Chemical Analysis of the Animal Remains of Burdiehouse. By Arthur Connell, Esq.

Since the Author's former communication to the Society, he has analyzed a portion of a bony fin-ray from the limestone belonging to a fossil fish which has been designated by M. Agassiz, Gyracanthus formosus.

The constituents were found to be,

Phosphate of Lime with a little Fluoride of Calcium, .	53.87
Carbonate of Lime, ...	33.86
Siliceous matter, ...	10.22
Potash and Soda, partly as Chlorides, . . .	.71
Bituminous matter, ...	.54
Phosphate of Magnesia, ... trace	
Animal matter, ... trace	
	99.20

He has also analyzed a portion of the fossil scales embedded in the limestone. These scales belong to a fossil genus of fish, to which the name of Megalichthys has been given by M. Agassiz, and which is supposed to approach in character to the Lepisosteus, or Lepidosteus of Agassiz. The scales were about three-fourths of an inch long by somewhat less in breadth, and possessed a fine lustre, and the usual delicately punctured surface. They were found to contain—

Phosphate of Lime, with a little Fluoride of Calcium,	50.94	
Carbonate of Lime, ...	11.91	
Siliceous matter, ...	33.10	36.58
Water, ...	3.48	
Potash and Soda, ...	.47	
Bituminous matter, ...	.12	
Phosphate of Magnesia, ... trace		
Animal matter, ... trace		
	100.02	

It is remarkable that the composition of these scales is very analogous to that of the scales of the recent Lepisosteus, if we suppose the perishable animal matter in the latter to be replaced by infiltration by the hydrated siliceous matter in the fossil scales. In those of the recent Lepisosteus, Chevreul found—

Phosphate of Lime,	46.20
Carbonate of Lime,	10.00
Gelatinous Animal matter,	41.10
Phosphate of Magnesia,	2.2
Fatty matter,	.10
Carbonate of Soda,	.10
	100

The result of the analysis of the bony rays of the Gyracanthus may also be compared with the constitution of certain recent fish bones. Those of the pike, as determined by Dumenil, consist of—

Phosphate of Lime,	55.26
Carbonate of Lime,	6.16
Animal matter,	37.36
Traces of Soda and loss,	1.32
	100.

If we suppose the animal matter to be replaced partly by siliceous matter and partly by carbonate of lime, the composition of the recent and of the fossil bones becomes very similar.

The ratio of the phosphate of lime to the carbonate of lime in the Coprolites, according to the analysis formerly communicated to the Society, does not differ much from the proportions in the above analysis of recent fish bones. The Coprolites may therefore be viewed as aggregated masses of fish-bone earth, the animal matter having decayed almost without any substitution, from fecal matter not possessing that structure and solidity which seem usually essential to the proper process of mineralization by infiltration. Since his former communication, the author has found a trace of fluoride of calcium in the Coprolites.

It is remarkable, that the limestone matrix itself contains a very decided trace of animal matter, doubtless derived from the great quantity of animal remains which have been entombed in it.